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AUTHOR Ipek, Ismail
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ABSTRACT

This paper examines variations of text density levels for learning in a computer-based instruction (CBI) tutorial from an integrated perspective, and addresses the following questions: (1) What is the text density? (2) What are the relationships among text density approaches? and (3) What are the contributions of text density for learning and how can perceptual skills and human factors be used for a CBI tutorial? Several ways of defining low- and high-density are given, and the effect on achievement of visual perception and reading skills is discussed. The variation of text density levels is addressed from the standpoint of chunking and manipulation of content information approaches. The structure of text density considers both the components of screen design and the elements of human information processing. Meaningful information occurs when interaction is provided from the intersection of text design, content and perception, indicating the relationship between text density and the perceptual cycle. Finally, text density variations of CBI screen design are affected by technological and human cognitive limitations, based on different visual perceptions, human-computer interaction strategies, and user interfaces. Three figures illustrate aspects of CBI and text density levels. (Contains 49 references.) (MAS)

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Considerations for CBI Screen Design with Respect to Text Density Levels in Content Learning From an Integrated Perspective

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Introduction

Theoretical and technological advances in the areas of psychology, learning, and computer technology have intertwined to produce the developing field of computer based instruction (CBI) which is a delivery format that teaches via a computer program. The CBI program guides the student through an instructional event and allows for practice time, the opportunity to assess the student's performance during instruction, and gives feedback and remedial help (Alessi & Trollip, 1985). For thirty years, it has been recognized as an effective tool for improving both learner performance and achievement (Kulik & Kulik, 1991; 1987; 1986; Kulik, Bangert & Williams, 1983; Kulik, Kulik & Cohen, 1980). It has also provided an opportunity for educators to control and study learning events.

Early CBI tutorials were created according to behavioral models. Today, psychologists have moved from using behavioral models to using cognitive models, which do take into account individual cognitive styles and processes. The move toward the use of cognitive models by psychologists has resulted in the need to find new methods of presenting information, in particular, the need for designing text layouts that facilitate the learning process (Grabinger & Amedeo, 1988). CBI developers have kept pace with advances in psychology and, as Park, Perez, and Siedel (1987) have indicated, the growing concern for teaching cognitive tasks such as problem solving, thinking, and language acquisition has caused CBI developers to begin incorporating cognitive learning principles and instructional strategies in their designs. Actually, CBI has become an effective tool for investigating cognitive learning principles and instructional strategies (Anderson, 1982).

The purpose of this paper is to examine variations of text density levels for content learning in a CBI tutorial from an integrated perspective. In this way, the purpose is addressed to these questions; (1) What is the text density ? (2) What are the relationships among text density approaches? (3) What are the contributions of text density for learning and how perceptual skills and human factors can be used for a CBI tutorial? At the end of the paper, considerations will be indicated and discussed to create effective text density levels in CBI screen design according to human-computer interaction and information processing as a perception style.

CBI Screen Design and Text Density Levels

High-density text contains more words than low-density text but may convey the same basic meaning. Variations in text density levels may effect the interaction between perception and communication. CBI designers are faced with certain technical limitations

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when presenting information via a computer screen. They must work not only within the confines of limited screen space, display area and page size, but must contend with the problems of resolution, forward and backward paging and limited cues regarding lesson length. Because computer text offers less flexibility than books in the presentation of text, it is more difficult to effectively present instructional material on the computer than it is in print (Morrison, Ross, O'Dell, & Schultz, 1988a; Morrison, Ross, & O'Dell, 1988b; Ross, Morrison, & O'Dell, 1989; Grabinger, 1983; Grabinger & Amedeo, 1988, 1985). Generally, text on screens has been found to be less legible than text on paper (Gould, Alfaro, Finn, Haupt, Minute & Salaun, 1987; Muter, Latremoulle, Treurniet & Beam, 1982).

These limitations suggested that research was needed regarding variation in text density levels on the computer screen. Because text density is significantly related to manipulating and reducing rules in content, the presentation of text using those rules helps maintain the meaning when the content is reduced. For example, when the content is reduced, the main idea may be lost unless text density rules have been effectively used to cue the learner's cognitive processes. The effective use of variations in text density materials in a program is essential in developing an alternative method of presentation in a CBI tutorial.

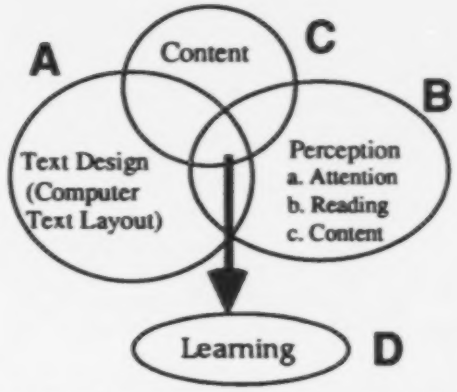
There are two approaches for understanding the density levels. One is high and low density levels in Morrison et al. (1988a, 1988b) studies. Another is chunking that indicates a process between nominal stimulus (actual text) and effective stimulus in Grabinger & Amedeo (1988). Density levels are determined based on the amount the information content has been reduced or the percentage of information that has been presented. In brief, the number of characters or number of words are used as density criteria in a text (Schultz, 1989; Morrison et al. (1988b). Low density text materials are generated from conventional text by (a) defining a set of rules for shortening the text; (b) having different individuals apply the rules to the rewriting of the text; and (c) requiring those individuals to arrive at a consensus on the final content (Morrison, O'Dell, Ross, Schultz, & Wheat, 1989a; Morrison et al. 1988a, 1988b). High density may indicate the actual text but it also can be text reduced from print materials, because research indicates that text density levels are a continuum (Schultz, 1989, Morrison et al. 1988b).

Learner control is an important option to investigate when talking about the effectiveness of the text density variable. Ross, et al. (1988a) suggested that text density level in content information provides attributes in organization and elaboration for different cognitive styles.

Grabinger & Amedeo (1988) suggested that text density is related to the meanings among words between nominal stimulus (actual text) and a reader's representation (effective stimulus). Effective stimulus refers to the integration of information, either within an existing schema or by creating a new schema (Grabinger & Amedeo, 1988; Morrison et al, 1988b; Neisser, 1976). Nominal stimulus refers to the environment (actual text) and to meaningful information in a text (Morrison et al, 1988c; Grabinger & Amedeo, 1988). Effective learning in a text is based on the amount of interaction with text design, perception and content. The relationships are essential to meaningful learning as indicated in figure 1. According to two different approaches in text density studies, the terms and meaningful learning in text density levels were found to support each other and make connections between two approaches. These connections are given in figure 2.

Chunking separates a sentence into phrases or idea units through the use of increased space or special cues. The aim of the chunking research is to

facilitate the connections of meanings among words between actual text and modified text (Grabinger & Amedeo, 1988). Understanding of actual text and modified text may remain as high density and low density respectively. Paragraph organization deals with hierarchical organization and systematic organization. As indicated by Reynolds (1979), "comprehension will be affected not only by the content of text, but also by its visibility and perceptibility and by the verbal capacity and intelligence of the reader" (p. 312).



A B C = D (meaningful information in a text)

Figure 1 The Relationship Between Text Density and Perception

Based on the approaches, the researcher has prepared a research proposal to determine the effects of variations of text density levels and cognitive style of field dependence on achievement in a CBI tutorial. For this purpose, CBI versions of the high-and low-density lessons were prepared directly from the print materials which are used to teach a fundamentals of geology course. The final versions of the low-and high-density CBI lessons consist of 145 modified (low density) and 145 (high density) frames respectively. In general, high density text was modified among 35 and 40 percent for each text.

For this study, the CBI version of Low-density text was created by researcher and reviewed by twenty graduate students, and finally validated by faculty members who taught fundamentals of geology course and who are expert in the field of development of CBI tutorials.

High-density text is defined as nominal stimulus that indicates environment (actual text). The difference between nominal stimulus and effective stimulus is based on the amount of information in the perceptual cycle (Neisser, 1976; Grabinger & Amedeo, 1988). For the study, the CBI version of high-density text was created by the researcher under the same criteria as low density from the printed materials.

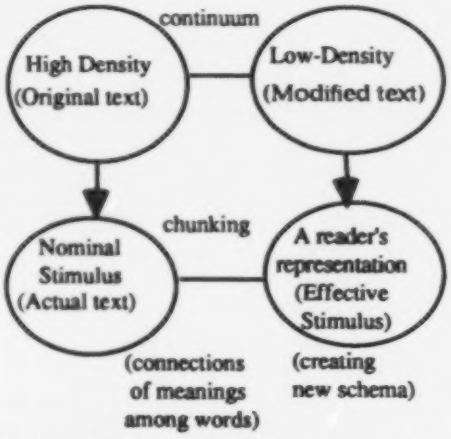


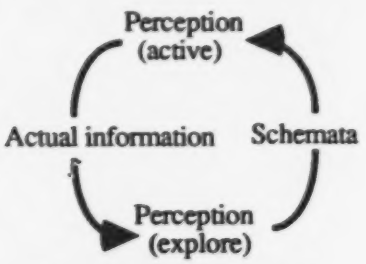
Figure 2 Interaction of Different Approaches in Text Density Levels

Two factors that come into play when talking about text density levels are visual perception and reading skills. Visual perception plays a role in achievement in so far as that the way in which individuals perceive a given set of information will have an impact on how well they can learn from the information which has been presented to them.

Perception time involves different

characteristics, for example, how learners perceive visuals from the text and which activities are most important in an event. The law of proximity in perception and the law of contiguity in memory both indicate that displays and elements which appear close together in space or time tend to be grouped in perception and memory. Display differences can be in terms of the time of presentation, in the spatial location within the display, or in the style or format (Fleming, 1989). As a result, proximity determines just how close in time and space visual images are to appear on the page, television, or computer screen.

The research of text format variables has focused primarily on the attention phase of the perceptual process. But certain limitations are imposed on comprehension when the main text is read from a computer screen because perception is a cycle that reacts to nominal stimulus and effective stimulus (Neisser, 1976). Human information processing as a perceptual style works in this cycle as indicated in figure 3 (Woods, 1984; Gale, 1993).



Adapted from Neisser (1976), Woods (1984), Grabinger & Amedeo (1988), and Gale (1993)

Figure 3 Perception as a Cycle

The process is based on perceptual action as well as readiness for particular kinds of optical structure. The perceptual action consists of three factors: available information (actual environment), schema, and exploration. These factors provide the perceptual cycle, which includes modifies, directs, and samples in this process (Neisser, 1976). Based on these considerations, the "cognitive link between reading and perception is important because it defines a psychological area that may be used to identify processes used by readers in perceiving CRT text and, it sets as a design objective the accurate translation of a nominal stimulus into an effective stimulus" without losing its original idea in a text (Grabinger & Amedeo, 1985).

One of the most important aspects of visual communication is perception. "Perception is often defined as awareness of objects in the environment" (Taylor, 1960, p. 51). Perception is an interaction between the perceiver and the object perceived. Every perception is a transaction. In other words, Fleming & Levie (1984) defined that "our perceptions are relative, selective and organized. Each of these characteristics provides some general guidelines for the designer" (p. 15). Perception deals with awareness of objects in learning environment.

Reading skills are important because the levels at which individuals read affect how they process the given information which, in turn, affects their achievement levels. Grabinger & Amedeo (1988) indicated that "reading, being a perceptual skill, involves not only attending to a stimulus, but also encoding that stimulus in a meaningful manner and cognitively integrating its information with existing knowledge or prior experience for assessing its meaning" (p. 190). Because information in CBI is presented in a format that must be read, reading speed, and reading rate are important learner characteristics in the learning process. Meaning among words must be held constant to manipulate the context of the information presented (Morrison, et al. 1988a, 1988b).

Instructional presentation is based not only on content but also on screen design. Text content determines which

information will be displayed on the screen. One obvious question is, what relationship exists between text content and text density? The content must contain a main idea and that main idea must be understandable, readable, and perceptible. The main point is how to design text on the computer screen without losing its original idea.

The functions of technological features in CBI text design are based on the effectiveness of text format variables and content information. Technological limitations in CBI text design can be reduced or manipulated to provide for more effective learning from the CBI lesson. To accomplish this, text format variables can be studied to determine effective text density levels for specific content while retaining necessary details and richness on the text screen. Text format details must be used to help present text with essential words or ideas for learning content information, addressing cognitive processes and assessing the amount of learning from the CBI text screen.

Most text screen design studies, in the literature, have been concerned with reading comprehension. Dole, Valencia, Greer & Wardrop (1991) identified the effects of prereading instruction on the comprehension of narrative and expository text. They found teacher-directed prereading of instructions more effective because, (a) it focused only on the most important information necessary for understanding the text, (b) it included direct and explicit instruction, (c) students are familiar with this type of traditional instruction. Because lesson content needs to be designed in accordance with the media attributes of the presentation medium selected, two points may be important. One is how much information is necessary for understanding the idea, and two, how direct and explicit, the presentation of text information must be. The following pages will discuss these questions.

Reading and Screen Design

Reading speed and learning process on the computer have been discussed in several studies (Gould & Grischkowsky 1983; Haas & Hayes 1985a; 1985b; Hansen, Doring & Whitlock 1978). The cognitive processes of reading and learning work together on the computer screen. It is important to tell that there is a link between reading and learning. The link provides psychological and technological environment to develop an effective CBI screen design. Chunking and a reader's representation of a text structure may vary from individual to individual. These findings suggest that successful format changes reinforce the reading and perceptual cycles (Grabinger and Amedeo,1988). The findings indicate that reading is an important part of screen design process.

Gould & Grischkowsky (1983) found that reading times were longer for subjects who read text displayed on a cathode ray tube (CRT) than for subjects who read the same text displayed on printed pages. Hansen et al. (1978) found that students who completed an examination on a computer screen required more time than students who completed it on printed pages. Haas & Hayes (1985a; 1985b) found that college students required more time to retrieve specific information from texts displayed on a computer screen than did subjects who read the same text on printed pages. Increases in reading time, interests and reading comprehension have been attributed to the unique technological characteristics of the computer display that may influence comprehension by effecting richer interactions between a reader and text (Reinking,1988), and increases in reading comprehension when texts are displayed by a computer may be confounded with readers' preconceptions about reading with the aid of computer (Clark, 1983).

In addition, Kintsch (1980)

indicated how interest is produced in stories. He defined emotional interest which is created through events that tend to arouse the reader; and cognitive interest, which results from certain relations between incoming information and background knowledge. Cognitive interest is related to the degree of novelty in a given text and how well the information can be related meaningfully to other sections of the text or stored knowledge.

Text design in CBI must be based on content information and the selected media (Grabinger, 1983; Grabinger & Amedeo, 1988). In computer text, screens serve as logical units of information. These logical processes pose special problems for designers who wish to present information in ways that help the learning process. In the text, cognitive processes of reading and learning have to work together. At this time, text design elements can help learners by attracting attention and holding interest on the text structure.

According to Hannafin & Reiber (1989), the use of indentation, leading and text chunking strategies appear equally valuable for both print and computer display. However, growing evidence suggests that many design principles are unique to the computer. Factors such as line length and character density of displays, for example, are likely to affect reading speed (Kruk & Muter, 1984).

Although learning remains largely unaffected, other features unique to electronic text, such as scrolling (Merrill, 1982), pixel density, and display resolutions are also likely to influence legibility. Additionally, research on text density (number of words per idea or concept) indicates that low-density text promotes achievement which is at least equivalent to normal text display, but reduces lesson completion time (Morrison et al. 1988b; Ross et al. 1988b). Interestingly however, high-density lesson versions were preferred by learners.

Morrison et al. (1988b) and Ross et al. (1988b) have conducted studies on text density as a contextual variable to test its effectiveness as an alternative method of displaying text on the computer screen. They used a text density strategy to manipulate the richness and detail of the information whereas chunking shortages only changed the display format of the information.

Operationally, the text density construct can be defined by the length of the material (number of words), redundancy of ideas, and depth of conceptual support for the main ideas (Morrison et al. 1989a, 1989b). The decrease in the number of words in the low-density text allowed the designers to make liberal use of white space and vertical typography to highlight and group ideas while maintaining an appropriate level of contextual support on individual screens. Maybe there is a problem with those definitions for measuring those variables. For instance, the questions that how to measure redundancy of ideas or depths of conceptual information in a text are come out.

Chunking was used by Grabinger and Amedeo (1988, 1985), and the manipulation of content was first used by Morrison et al. (1988b) and Ross et al. (1988b). There was a shared point between two approaches, which indicated content without losing the main idea. According to Morrison et al. (1989b), "text density, on the other hand, allowed learners to manipulate contextual properties of the lesson that affected how the lesson appeared rather than chunking the basic information content" (p. 168).

The text density study of (Morrison et al. 1988b; Ross et al. 1988b), can be summarized for presentation modes and text density levels as follows:

1. No differences in learning occurred between low-and high-density groups. 2. The high-density group took 34 percent more time to complete the lesson. 3. Subjects judged the high-density material as slower moving and low-density material as more sufficient than did the print subjects. 4. Comparisons of the full-vs partial-LC (Learner control) conditions indicated no significant differences on achievement, attitudes, or density selections. 5. Reading rate was found to be the only significant predictor of these preferences: subjects selecting CBI were faster readers than those who selected print (Morrison et al. 1989a).

According to the view of Neisser (1976), the cognitive structures are the anticipatory schemata that prepare the perceiver to accept actual information. Because, he further indicated that" we can see only what we know how to look for, it is these schemata that determine what will be perceived" (p. 20).

Messick (1976) identified more than 20 cognitive styles. According to Messick (1976), the field independent person tends to articulate figures as discrete from their backgrounds and can more easily differentiate objects from the embedding context, whereas the field dependent person tends to experience events globally. Similarly, Jonassen (1989) indicated that the field dependent learner views information on the computer screen globally. This definition of field dependence suggests a link between text design, specifically, text density layout, and the cognitive style of field dependence.

CBI developers must understand the various ways individuals perceive and process information if they are to create more effective text and screen designs and thus facilitate the learning process. When learners witness an event, it is likely that each learner will describe a somewhat different experience. Their responses are a result of their individual perceptions which are influenced by differences in gender, cognitive styles, social interactions, interests, achievements, learning styles, and abilities (Witkin, 1976). The individual differences in the ways in which information is organized and processed are known as cognitive styles.

Text Density, Cognitive Style, and Visual Perception in CBI

The literature on computer screen design tends to follow one of two approaches. The first approach focuses on creating effective screen design by means of manipulation of typographical variables. A second approach to computer screen design focuses on the manipulation of the content. Morrison et al. (1989a;1989b) suggested additional variables for designing effective CBI text screens. One is text density which manipulates the context of the information presented, and another is screen density which is the measurement of the amount of information presented at one time on the screen. This paper deals with text density in CBI screen design and how cognitive processes interact with visual format.

By varying text density approaches, Morrison et al. (1989a, 1989b, 1988b) and Ross et al. (1988b) found empirically based data regarding achievement and interaction time that was statistically significant on three of four measures, calculation, transfer and delayed retention.

Grabinger & Amedeo (1988) investigated perceptions of viewers in terms of text format variables covering structure, organization and simplicity. They found that the overall effect of the designs is one of organization. While structure refers to a hierarchical and systematic arrangement, organization refers to a segmented or blocked arrangement. The features of narrow text, double spacing, and organized paragraphs contribute to a feeling of ease, spaciousness, and simple manageable text. As a result, a content analysis of participant descriptions of text types

indicates that "different emphasis is placed on different criteria by subjects when perceiving CRT text variability" in the study (p. 203).

A reader's representation of text structure may vary from individual to individual (Grabinger & Amedeo, 1988). This suggests the need for a set of text format design guidelines likely to be based on perception and reading processes themselves, rather than on the effective stimulus alone.

As a result, these questions must be answered to create effective screen design in CBI. What type of text density do students prefer? According to Schultz (1989), students' preferences for text density at 53%, 31%, 26%, and 22% were analyzed. The 31% density screens were preferred, with 26% second, 22% third, and 53% last ($p < .10$). The empirical data seem to support the idea that there is indeed an optimum in screen density. But it does not indicate the amount of interaction between cognitive style and text density. Cognitive style of field dependence is a continuum (Oltman, 1968). Text density was also found as a continuum in learning (Schultz, 1989). Research is needed to indicate an interaction level between two continuum levels. How does the density of text information interact with the cognitive style in the learning process? This question considers an adaptive strategy in CBI tutorial (Ross & Morrison, 1988c). Text density as an adaptive strategy will serve to stimulate more specific efforts to design text display according to media attributes and cognitive styles for CBI tutorial. The CBI tutorial will have personal interests and preferences as well as contextual lesson properties for effective learning.

During the past few decades, cognitive style has been studied to assess its role in student learning. Recently, cognitive style research has turned toward the educational process. According to Messick (1976), cognitive style as information processing describes the learner's typical modes of perceiving, thinking, problem solving, and remembering. He also indicated that each cognitive style has distinct abilities. Each individual has preferred ways of organizing all that he sees, remembers, and thinks about, and these individual differences are known as cognitive styles.

The relationship between the term cognitive style and the term learning style has found different viewpoints in the literature. The term cognitive style has often been used interchangeably with learning style, however, Claxton and Ralston (1978) argued that cognitive style was only a type of learning style. Keefe (1979, 1982), extending this view of a cognitive style as a subcategory of learning style, indicated that" learning styles are cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to a learning environment" (p. 16, 44).

Although relationships between cognitive styles and reading abilities have been studied in some previous research (Hidi & Baird, 1988; Kintsch, 1980; Reinking, 1988), no studies have investigated the relationship between cognitive styles and text density.

Conclusions

The arguments put forward in this paper concerning negative and positive approaches to text density and human factors in CBI screen design in the future of software design and instructional design can be summarized as follows.

To develop text density levels, we need a clear definition of text density in the CBI. Although there are some definitions for the conventional design and for a CBI screen design, there is a lack of definition. For instance, text density would be a summary of content or the amount of perception, or summary of information, or summary of main idea, a number of characters/words or combination of two and more. Because

the values for designing rules in text density are so flexible and not objective, but the lack of information can be reduced by testing techniques such as item analysis for text questions in content or text on the screen. The process can provide a support for instructional designers and software designers in CBI screen design.

Research is needed to investigate how learners in different cognitive styles are affected from different text density display according to their reading, comprehension, and perception skills. This considers investigating perceptual views in information processing and individual learners characteristics according to human memory system.

Human-Computer Interaction (HCI) and Computer-Human Interfaces (CHI) are important design strategies for effective CBI screen design. These factors may affect all human senses for creating and producing meaningful instructional materials in their purposes. Because there are three components that include cognitive factors, the computer technology, and user interface. Those factors affect human information processing with respect to human cognitive limitations and hardware limitations.

As a result, text density variations in CBI screen design should be evaluated and created according to needs in instruction and learning, such as interests, learners characteristics, HCI strategies, human cognitive limitations and measurement techniques.

Summary

This paper has addressed variations of text density levels of CBI screen design from the standpoint of chunking and manipulation of content information approaches. The structure of text density considers both the components of screen design and the elements of human information processing as a perceptual style that deals with using technology and understanding learner characteristics.

Sophisticated CBI screen design, well designed format variables with text, and quality software design would be possible with using human-computer interaction strategies and understanding of individual perceptual skills for both novice and experienced users according to cognitive limitations and technological limitations.

Meaningful information occurs when the interaction is provided from the intersection of text design, content and perception. The interaction indicates the relationship between text density and perceptual cycle. Information processing as a perceptual cycle presents an attention and interests levels for learners in CBI. The visual perception shows how visuals deal with human eye movements in CBI screens.

Finally, text density variations of CBI screen design are affected from human cognitive limitations and technological limitations. Those effects are based on different visual perceptions and HCI strategies, and different user interfaces.

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